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Cancer Mortality in U.S. Counties with Plastics and Related Industries

by Thomas J. Mason*

Counties in the United States have been identified with chemical establishments whose primary manufacturing processes use vinyl chloride. Site-specific cancer mortality comparisons have revealed an excess of multiple myeloma in males associated with two of the manufacturing categories, synthetic rubber and synthetic fibers. A causal relationship between these manufacturing categories and multiple myeloma could not be established. An industry-based assessment of the occupational contribution to this excess is needed to evaluate the etiologic importance of this relationship.

Introduction

Angiosarcoma of the liver has been identified among workers who are heavily exposed to vinyl chloride (*1,2*). There is the possibility that individuals residing in areas with manufacturing plants using vinyl chloride may be exposed to this chemical. The present investigation of site-specific cancer mortality by county evaluates the risk of malignancy among residents of counties in the United States with possible environmental exposure to vinyl chloride.

Methods

The 1963 Census of Manufacturers (*3*) was used to identify counties with chemical establishments identified by Standard Industrial Classification (SIC) codes 2821–2824. These establishments are engaged primarily in manufacturing plastics materials and synthetic resins (SIC 2821), synthetic rubber (SIC 2822), cellulosic man-made fibers (SIC 2823), or synthetic organic fibers (SIC 2824). Vinyl chloride is not used in manufacturing cellulosic fibers. The category was included, however, to complete SIC Groups No. 282 which was selected to represent plastics and related industries. The number of people employed in each of the four manufacturing categories was then obtained for individual counties in the United States. As such this is a conservative estimate because classification is a function of the main items manufactured. Counties in each of the four manufacturing categories were ranked on the proportion of the total county population employed. Those counties in the upper quartile of the distribution of nonzero proportions for each manufacturing category were retained as study counties. As a comparison group, two counties were chosen for each study group county, matched by state and the per cent of the population living in urban areas (*4*).

Site-specific cancer mortality rates were calculated for the white population in study and control counties as well as the total United States for the period 1950 to 1969 and its four 5-yr component intervals. Mortality data by age, race, sex, cause of death, and county of usual residence were provided by the National Center for Health Statistics. Population estimates were obtained from published census statistics of 1950, 1960, and 1970, and intercensal estimates were derived by linear interpolation. All rates were age-adjusted by the direct method with the total U.S. population 1960 as the standard, and are expressed per 100,000. Rates were calculated for 29 individual sites and 6 combined sites (*5*). The variance

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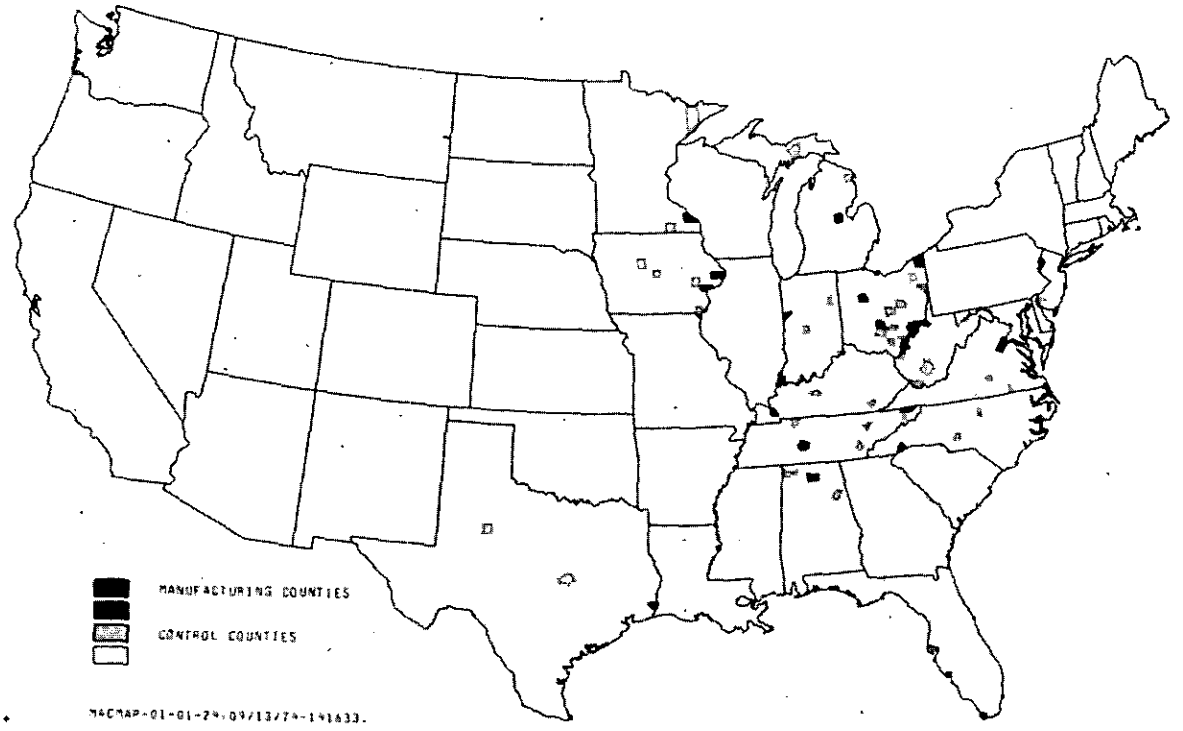

FIGURE 1. Study counties with chemical establishments primarily engaged in manufacturing plastics materials and synthetic resins with associated controls. Upper 25% of counties ranked on proportion of their total 1963 population employed in manufacturing category SIC 2821 and controls.

for each mortality rate was calculated by following the methodology of Chiang (*6*). Comparisons for males were made to the total United States as well as to control counties, utilizing a standardized normal test of significance at $p = 0.05$ (*7*). Comparisons for females were made for only those sites for which a significant male excess had been detected.

Results

Figures 1–4 identify study counties (upper 25% of the distribution of proportions of individual county populations employed in each manufacturing category) and their respective controls. The geographic patterns are distinct for each category, since no county satisfied the selection criterion for more than one type of manufacturing. Demographic characteristics for individual counties (Table 1) were taken from the 1960 Census (*4*). There are marked differences for urbanization between the categories, i.e., synthetic rubber manufacturing takes place in highly urbanized areas, whereas fibers are made in rural places. Age-adjusted cancer mortality rates for each manufacturing category were compared initially to total U.S. rates, and then to control counties. Table 2 presents only those rates for sites in white males which were significantly ($p < 0.05$) greater than the total U.S. and control counties. No anatomic site of cancer was found excessive in more than one manufacturing category for the 20-year period 1950–69. Also, no significant excesses were found for counties manufacturing cellulosic fibers.

Due to disease classification changes in 1958, rates for primary liver cancer [ICD 155.0, Seventh Revision ICD (*8*)], were calculated for the interval 1958–1967. This includes angiosarcoma deaths which were not separable from other forms of liver cancer in our mortality data. Of the counties considered, only those with synthetic rubber manufacture had

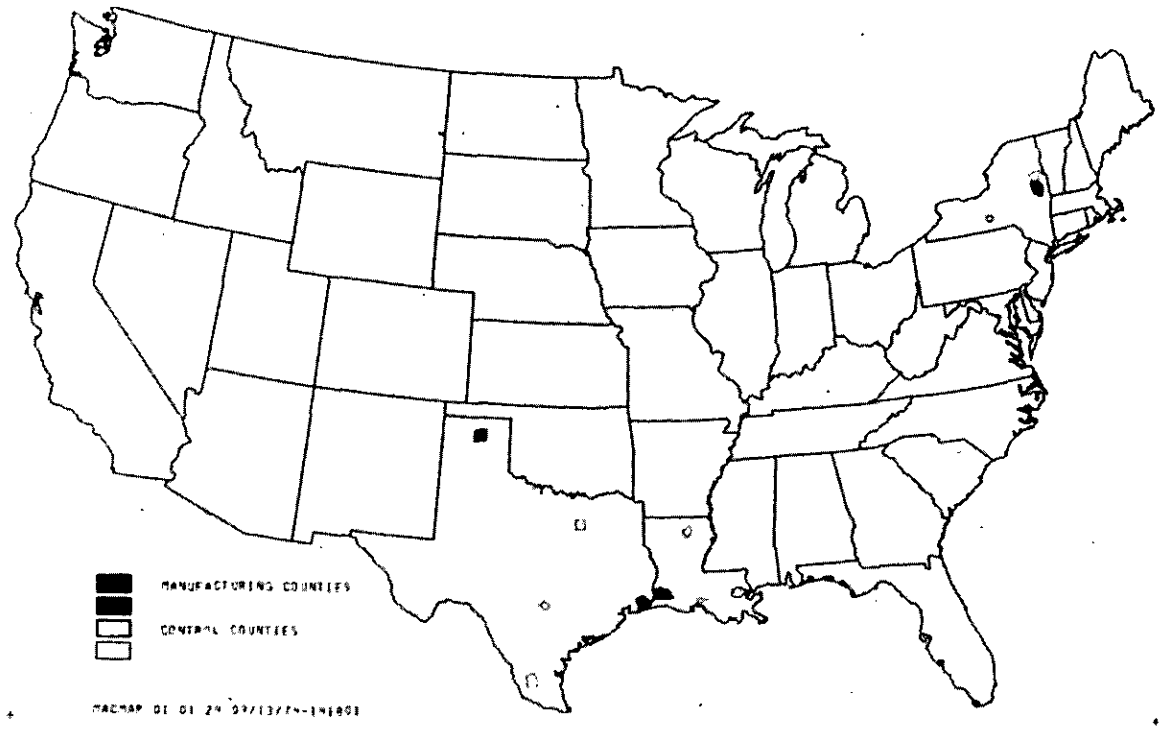

FIGURE 2. Study counties with chemical establishments primarily engaged in manufacturing synthetic rubber with associated controls. Upper 25% of counties ranked on proportion of their total 1963 population employed in manufacturing category SIC 2822 and controls.

consistently greater rates for liver cancer in general than the total U.S. rate of 1.34 for white males. However, the rate of 2.71 for counties manufacturing synthetic rubber was not significantly greater than that of 2.03 for their control counties.

Comparisons of data for females by manufacturing category were restricted to those anatomic sites for which a male excess had been detected. The only site with a significant excess in comparison to both total U.S. and controls was lung cancer in counties with synthetic rubber manufacture. The rates were 7.74 (study group), 6.72 (control), and 6.29 (total U.S.).

Table 1. Characteristics of counties for manufacturing categories and controls.

	Plastics (SIC 2821)	Synthetic rubber (SIC 2822)	Cellulosic fibers (SIC 2823)	Synthetic fibers (SIC 2824)
Number of counties	21	4	5	5
Total population, 1960	979,417	514,649	130,105	220,798
Range employed in the specific category, %	0.5–8.7	0.6–2.4	4.3–10.1	2.4–4.4
Urban, %*				
Manufacturing	50.2	80.2	33.9	43.1
Control	47.0	90.4	48.2	41.7

*Weighted averages of individual county estimates.

Time Trends Associated with Manufacturing Categories

Time trends were investigated by subdividing the interval of study (1950–1969) into four 5-yr intervals and comparing mortality rates for all sites of cancer which were included in the 20-yr comparisons. Significant differences for males were detected for two sites (cancer of the rectum and multiple myeloma) which were not at excess for the total time period, and

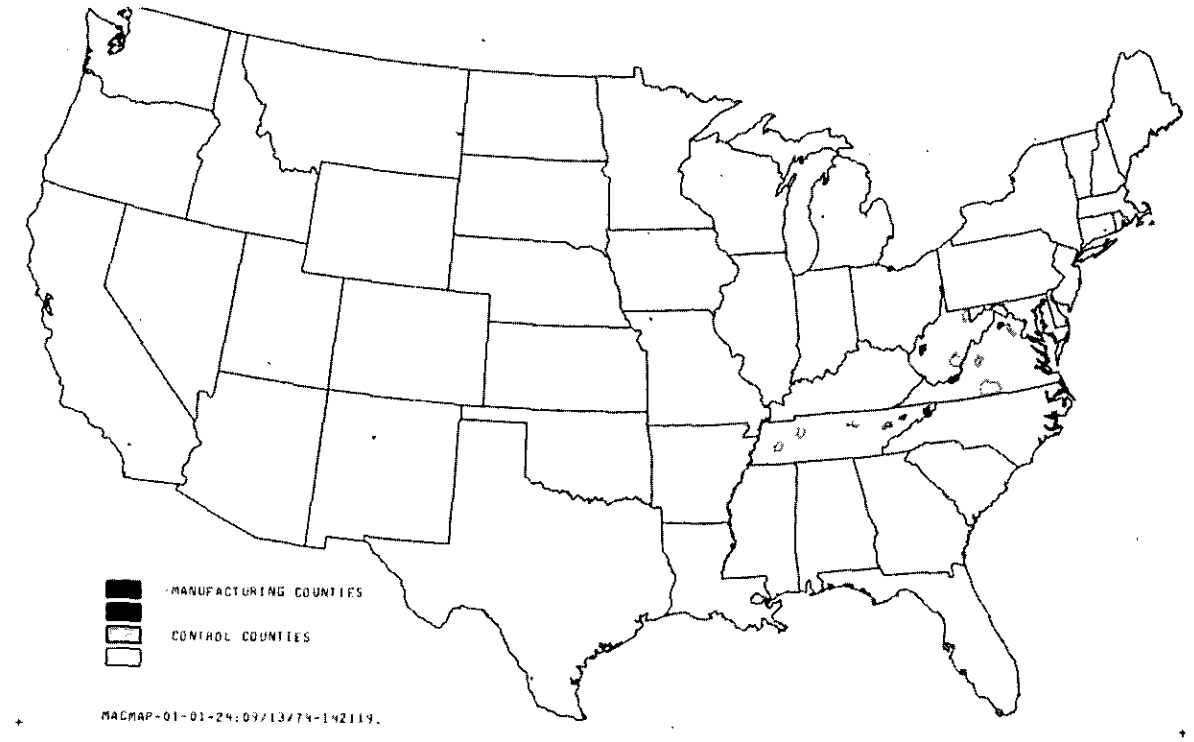

FIGURE 3. Study counties with chemical establishments primarily engaged in manufacturing cellulosic man-made fibers with associated controls. Upper 25% of counties ranked on proportion of their total 1963 population employed in manufacturing category SIC 2823 and controls.

Table 2. Age-adjusted mortality rates per 100,000 white males by manufacturing category for cancer sites which were significantly ($p < 0.05$) greater than the total U.S. and control counties (1950–1969).

	Mortality rates per 100,000		
	Manufacturing counties	Total U.S.	Control counties
Plastics (SIC 2821)			
Testis (ICD 178)[a]	0.91	0.83	0.71
Other endocrine (ICD 195)[b]	0.39	0.31	0.24
Synthetic Rubber (SIC 2822)			
Nasal sinuses, etc. (ICD 160)	0.73	0.43	0.37
Lung (ICD 162,163)	48.69	37.98	45.08
Bladder (ICD 181)	7.84	6.78	6.35
Synthetic Fibers (SIC 2824)			
Multiple myeloma (ICD 203)	2.24	1.76	1.79

[a] All ICD numbers refer to the International Classification of Diseases, Sixth Revision (*9*).
[b] Includes suprarenal, parathyroid, thymus, pituitary, and pineal glands.

these were excessive only in the interval 1965–1969. For counties manufacturing plastics materials and synthetic resins, cancer of the rectum in males remained constant in contrast to a decline in the control counties and the total U.S. The rates were 7.30 per 100,000 per year for manufacturing, compared to 5.24 in control counties and 6.62 in the total United States. For females, mortality rates for rectal cancer declined over time in both manufacturing and control counties. Mortality rates for multiple myeloma among males in counties with synthetic rubber manufacture did not differ from controls and total United States through 1964. For 1965–1969, however, the rates were 3.46 (study group), 2.11 (total U.S.), and 2.01 (control). There was no comparable difference among females.

Decreasing Trends

Mortality rates decreased in time for cancer

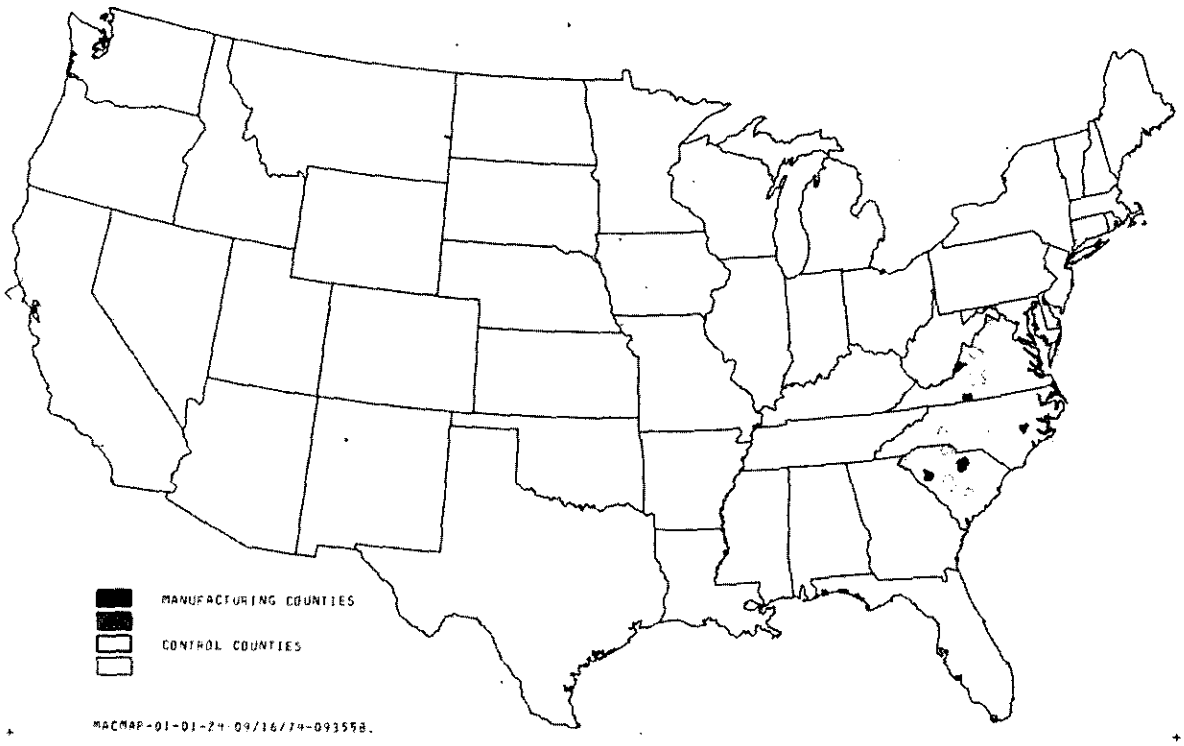

FIGURE 4. Study counties with chemical establishments primarily engaged in manufacturing synthetic organic fibers with associated controls. Upper 25% of counties ranked on proportion of their total 1963 population employed in manufacturing category 2824 and controls.

of the testis in counties with plastics and synthetic resin manufacture, and for cancer of the nasal cavity and accessory sinuses among males in counties with synthetic rubber manufacture. The rate of decline for testis was greater for manufacturing counties than control counties and total United States. For nasal cavity and accessory sinuses, mortality rates declined at a greater rate for control counties than the total U.S. and counties with synthetic rubber manufacture.

Increasing Trends

Lung cancer among males increased at a greater rate in control counties than in counties with synthetic rubber manufacture. The increase in these manufacturing counties was greater than for the total U.S. For all other sites given in Table 2 (other endocrine, bladder, and multiple myeloma) the rate of increase was greater in the manufacturing counties than the controls, and also greater for both county categories than the United States rate for change.

Discussion

This investigation of the possible health hazard to residents of counties in the United States with chemical establishments using vinyl chloride has several limitations. The effect of confounding variables on the results could not be completely controlled for. The selection criteria for control counties takes into consideration the effect of urbanization and also regional differences in diagnosis. However, the effect of cigarette smoking which is associated with cancers of the lung and bladder (*10*) could not be controlled for. The finding of excess mortality for lung cancer among men and women in counties with synthetic rubber manufacture could be due to differences in smoking habits, and not be directly related to the manu-

facturing process. There is also a dilutional effect which may prevent the identification of excesses among small subsets of the population with relevant exposure. The reported excess of angiosarcoma of the liver among vinyl chloride workers was not detected in this investigation. This is due to the grouping of diagnoses in disease classification as well as the small number of cases. No refinement of the data to smaller population units than counties, however, was possible.

Mortality rates for cancers of the nasal cavity and accessory sinuses and bladder among males were excessive only in counties with synthetic rubber manufacture. This finding may be unrelated to the manufacturing of synthetic rubber, but is consistent with previous findings suggesting that chemicals may be carcinogenic at the sites of absorption and excretion (*11*).

Occupational studies have reported excess mortality due to cancers of the digestive system, liver and biliary tract, lung, brain, and lymphatic and hematopoietic tissues among vinyl chloride workers (*1,2*). The only site-specific comparison which detected increases for males in more than one of these manufacturing categories was for multiple myeloma. Mortality rates for this site were greater for counties with synthetic rubber and synthetic fiber manufacture than their corresponding controls and the total United States. An excess of multiple myeloma in farmers has been reported (12). This may relate to the male excess in the rural counties (43% urban) with synthetic fiber manufacture. However, it does not explain the finding of an excess for males in counties with synthetic rubber manufacture (80.2% urban). Multiple myeloma is included in the broad classification for cancers of lymphatic and hematopoietic tissues. An evaluation of the contribution of mortality from this site to the excess for the broader classification among vinyl chloride workers is needed.

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